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Time Series Analysis of Egg Prices Across Nigeria for Sustainable Food Security

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ABSTRACT

The ability to forecast the future has always been of great interest to humanity, in order to take one kind of informed decision or the other. In this research work, time series analysis such as Auto Regressive Integrated Moving Average (ARIMA) model was employed to analyse the monthly price of egg (medium size) across all 6 geo-political regions in Nigeria from 2016-2019 with intent to forecast future prices of egg in the 6 regions. Two ARIMA models (ARIMA (3,1,0) & ARIMA (3,1,1)) were used on the dataset, with ARIMA (3,1,0) found to be more suitable for the dataset used. The results show a steadily rising price of eggs across all zones in the country, projecting into 2022; and this could in turn affect the ability of the average Nigerian to afford this meal that is very rich in protein, vitamins and minerals. This rising price could be attributed to the high cost of poultry feed as well as other production inputs. In the long run, the rising prices of poultry eggs may lead to low patronage. Hence both private farmers and government agency should device inclusive policy to stem the tide of this rising cost of eggs for sustainability of food security in the country.

Keywords*:* Egg, Time Series, Food Security, Protein, Vitamins, Minerals

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1. INTRODUCTION

As Nigeria continue to seek food security, an important aspect to look at is the area of food pricing within the country. Apart for the issue of affordability by its citizenry, stakeholders and investors would be interested in knowing if a venture is worth it or not. In the light of this; pricing (past, present and future) of a commodity can play an important role in decision-making. This work is an attempt to forecast the prices of medium sized eggs in the country to aid decision-making by existing and prospective investors and consumers. The Food and Agricultural Organization of the United Nations (FAO) specifies a daily requirement of 65 gm to 75 gm of total protein, with 40% gotten from animal protein (Evbuomwan, 2006). Poultry egg can greatly compliment that demand for protein as one large egg provides 6.5 gm of protein (Duffy & McCarthy, (n.d)), in addition to several essential vitamins and minerals. Poultry egg is a very important part of meal and it is consumed in different forms in all geo-political regions in the country. Factually, eggs have been used as a source of food by humans throughout the world since time immemorial (Duffy & McCarthy, (n.d)). Egg is a meal so important that it has a whole day dedicate to it by the International Egg Commission (IEC) known as "*World Egg Day*".

The world egg day was announced by the IEC in a conference in Vienna on October 8, 1996, and since then, it has been celebrated yearly world-wide (News18, 2021). It is celebrated every year on the second Friday in October. The aim is to sensitise people all over the world on the importance of eggs in their daily nutrition and encourage people to include eggs in their daily diet. (World Egg Day, 2020). Poultry can be reared in small scale (capacity of 1 to 2,500 birds), medium scale (capacity of 2,501 to 10,000 birds) and large scale (capacity of over 10,000 birds) (Mackenzie *et al.,* 2020). Evbuomwan (2006) asserted that Protein from livestock was more nutritionally superior to that of vegetable source as it contains a complete range of amino acids that are essential for maintenance of health. Despite this seemingly nutritional advantage, a Nigerian consumes only about an average of 65 eggs per annum, compared to the United States of America (USA) where the average consumption is 279.8 eggs per person (Mackenzie *et al.,* 2020).

Fig 1: Egg Production In Nigeria
Source: https://duduregbe.com/service/egg-production/

In this research work, time series analysis such as Auto Regressive Integrated Moving Average (ARIMA) model was employed to analyse the monthly price of eggs (medium size) across all the 6 geopolitical regions in Nigeria from 2016-2019 with intent to forecast future prices of eggs. Two ARIMA models (ARIMA (3,1,0) & ARIMA (3,1,1)) were used on the dataset, with ARIMA (3,1,0) found to be more suitable.

2. REVIEW OF RELATED WORKS

Time series has found several applications in the agricultural field in forecasting of various entities. Kumar and Bhramaramba (2018) did a research on agriculture food production with intent to unravel the underlying structure of the time series so as to fit an appropriate Auto Regressive Integrated Moving Average (ARIMA) model. In another work, with a desire to forecast the total food grain production and productivity from 2018-2019 to 2025-2026 based on past history from 1950-51 to 2017-2018, Puneet Dheer (2019) employed time series and its off-shoots such as ARIMA, (ARNN) (Auto Regressive Neural Network) and ARIMA-ARNN hybrid model. The work used performances criteria such RMSE (Root Mean Square Error) and MAPE (Mean Absolute Percentage Error), and posited that ARNN (3, 4) and ARNN (4, 3) model performed best for modelling both the production and yield respectively.

Time series are not only used for forecasting, but can also be employed in food safety concerns. In 2007, several states in the United State of America experienced an outbreak of Salmonellosis (a foodborne illness). This prompted the U.S. Centers for Disease Control and Prevention (CDC) and state departments of health to carry out an investigation which findings showed that the foodborne illness was caused by the consumption of a certain brands of peanut butter (Bakhtavoryan *et al.*, 2018). This led to a recall of the said brands. Employing time series analysis, Bakhtavoryan *et al.,* (2018), carried out a research on the demand for peanut butter in the wake of the product recall. The study found that the outbreak variable had a negative impact on the quantity purchased of peanut butter, when the Vector Error Correction (VEC) model was applied; as opposed to a structural/econometric model.

The pursuit for equilibrium in demand and supply of food product in Nigeria can also be determined using time series. Ojogho *et al.,* (2012) examined Nigeria annual rice supply and demand (from 1960-2007) using the Error Correction Model approach (ECM). The study showed that the demand (importation) for rice in the country has increased steadily from US$100,000 in 1970 to US$259 million annually. Furthermore, the study averred a disequilibrium between supply and demand in the short-run but re-equilibrates at 0.043 at the long run equilibrium. Time series can also find application in determining the cultivated area and production of certain crops (such as maize). Using ARIMA (1,1,1), Badmus & Ariyo, (2011) were able to project 9 years into the future to peg Nigeria's cultivate area of maize in 2020 at 9229.74 thousand hectares from earlier (1979 & 2007) cultivation Area of 425000 and 9244000 hectares respectively. Similarly, using ARIMA (2,1,2) the production of maize as forecasted stood at about 9952.72 thousand tons (in year 2020) bound by lower and upper limits of 6479.8 thousand tons and 13425.64 thousand tons respectively from 488,000 tons (in year 1980) and 9,876,000 tons (year 2008) (Badmus & Ariyo, 2011).

3. MATERIALS AND METHOD

In this research work, ARIMA (3,1,0) and ARIMA (3,1,1) were adopted as the data collected were not stationary. The data analysis was carried out using IBM SPSS statistical tool.

Data Description.

Dataset were collected from the repository of National Bureau of Statistics. The data represent the price of a dozen medium sized eggs and the prices of a single medium sized egg across the 36 states and the Federal Capital Territory (FCT) in Nigeria from January 2016 to March 2019.

Data Preprocessing

Considering that the dataset collected included both the prices of dozen and single eggs (medium size), the preprocessing started by extracting only the dozen prices of the eggs. Furthermore, the states in the country were separated into their respective geo-political zones as shown in Table 1 below; this is also visualised in the map of Nigeria depicted in Figure1 below. After which the mean prices was determined in each of the zones. It is this mean prices that was analysed.

Table 1: Geo-Political Zones In Nigeria And Their Respective States

S/N	Name of Zone	States making up the Zone
1	South South	Akwa Ibom, Bayelsa, Cross River, Rivers, Delta & Edo.
2	South East	Abia, Anambra, Ebonyi, Enugu & Imo.
3	South West	Ekiti, Lagos, Ogun, Ondo, Osun & Oyo.
4	North Central	Benue, Kogi, Kwara, Nasarawa, Niger, Plateau & FCT.
5	North West	Kaduna, Kano, Katsina, Kebbi, Jigawa, Sokoto, Zamfara.
6	North East	Adamawa, Bauchi, Borno, Gombe, Taraba & Yobe.

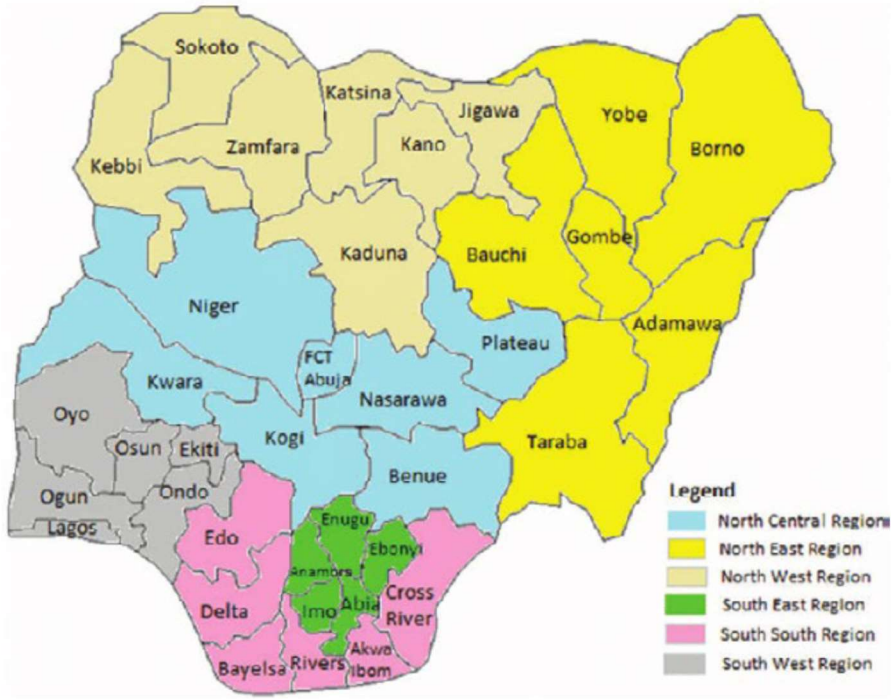

Figure 2. Map of Nigeria showing all the 6 geo-political zones (Mackenzie et al., 2020).

Medium Sized Egg Prices across the 6 Geo -Political Zones

The prices of a dozen medium sized eggs from January 2016 to March 2019 is summarised in Table 2. A cursory look at the table reveals an increase in the prices during the period under study. South South zone had the highest price at N358.23 per a dozen medium sized egg as at January, 2016, while the North East had the lowest price at N250.31 per dozen. However, by March 2019, the South East geo-political zone posted the highest price of a dozen medium sized eggs (N511.79). Nevertheless, the highest percentage increase took place in the North Eastern region of the country (73.73%) by March, 2019.

Table 2: Summarizes prices of a Dozen Medium Sized Eggs from January 2016 to March 2019 across the 6 Geo-Political Regions in Nigeria

S/N	Geo-Political Zones	Price of Dozen Medium sized Eggs (in Naira) as at January 2016	Price of Dozen Medium sized Eggs (in Naira) as at March 2019	% Increase
1	South South	358.23	484.96	35.38%
2	South East	340.59	511.79	50.27%
3	South West	326.15	432.02	32.46%
4	North Central	340.84	439.51	28.94%
5	North West	345.05	437.77	26.87%
6	North East	250.31	434.88	73.73%

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Figures 1a and 1b represent the dataset zone by zone in a sequential chart. Though fluctuations were observed in all zones, but a steady increase in a dozen price of medium sized eggs can be observed in all the zones.

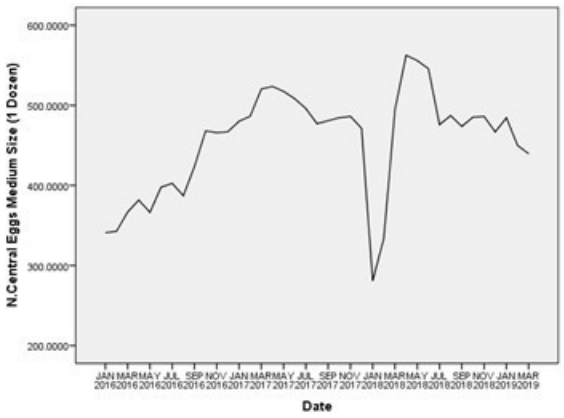

Figure 1b: Visualisation of a dozen price of medium-sized eggs in South South zone.

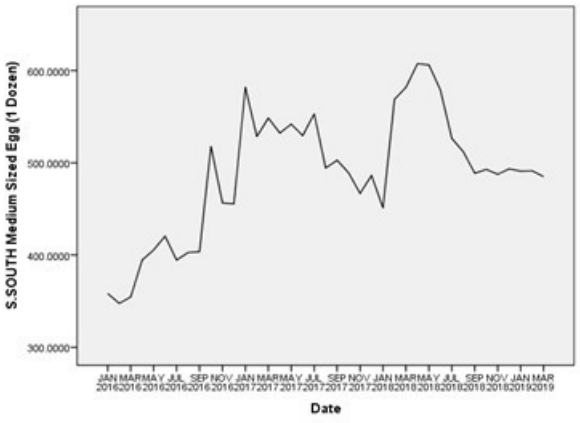

Figure 1b: Visualisation of a dozen price of medium-sized eggs in South South zone.

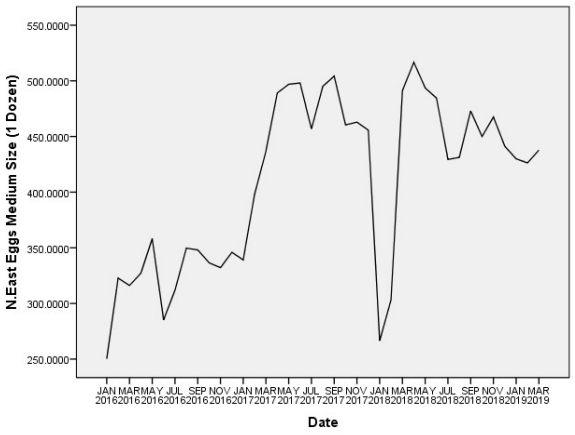

Figure 1c: Visualisation of a dozen price of medium-sized eggs in North East zone.

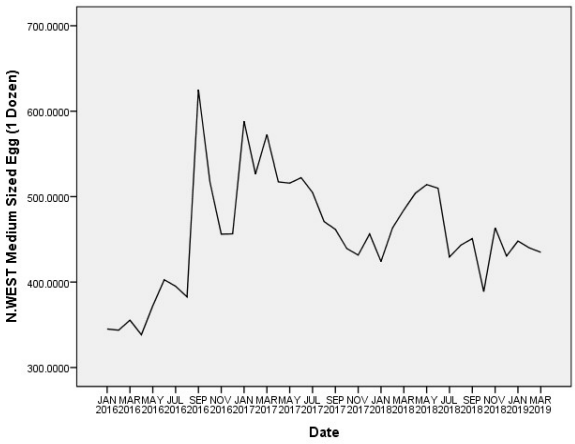

Figure 1d: Visualisation of a dozen price of medium-sized eggs in North West zone

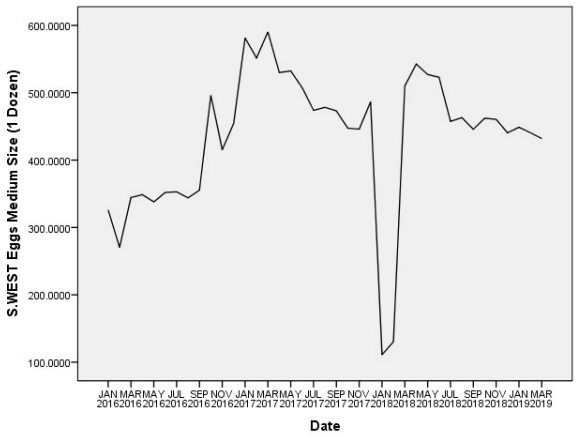

Figure 1e: Visualisation of a dozen price of medium-sized eggs in S. West geo-political zone.

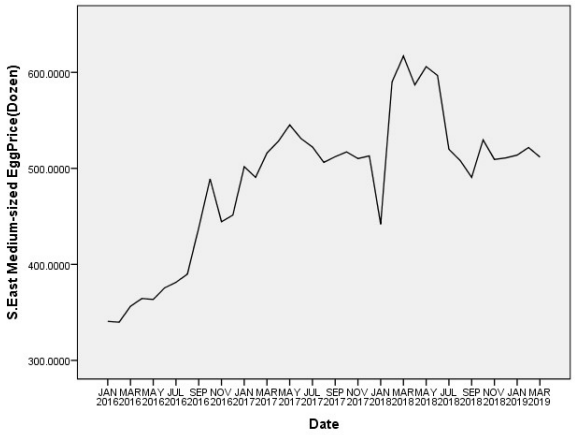

Figure1f: Visualisation of a dozen price of medium-sized eggs in South East zone.

4. DISCUSSIONS

Data Analysis

The analysis started by making the sequential chart stationary. A careful look at Figures 1a – 1f above shows that all the sequential charts are not stationary, which is an undesirable condition if the ARIMA model should be used. By stationary we mean the time series data need to have a constant mean and a constant variance over time. The charts in Figures 2a – 2f depict the stationary graphical representation of the datasets from the 6 different geo-political zones applying a difference of 1. A non–stationary data is usually made stationary through differencing.

$W_t = Y_{t+1} - Y_t$ ---------- (1)

Where Y_{t+1} is the previous price of a dozen medium sized eggs.
Y_t is the next price of a dozen medium sized eggs.
W_t the new series after differencing.

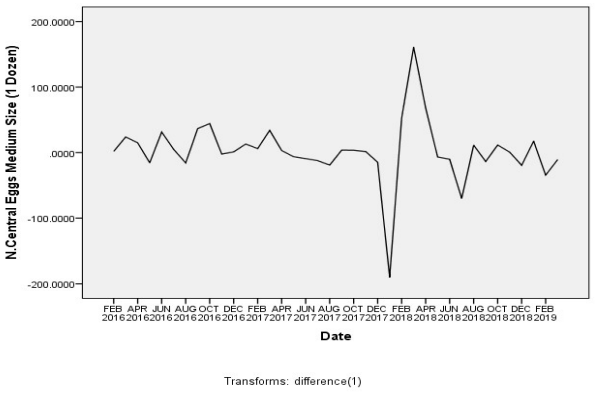

Figure 2a: Visualisation of North Central zone Stationary chart using a difference of 1

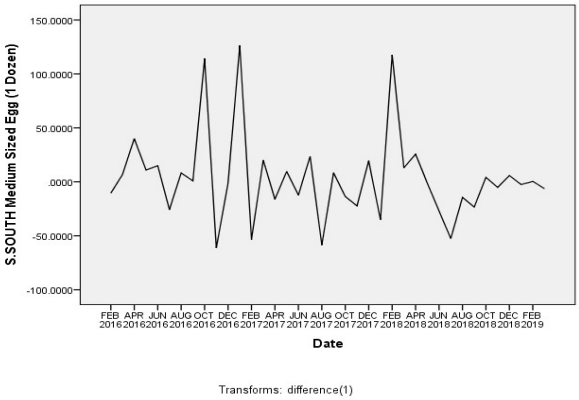

Figure 2b: Visualisation of South South zone Stationary chart using a difference of 1

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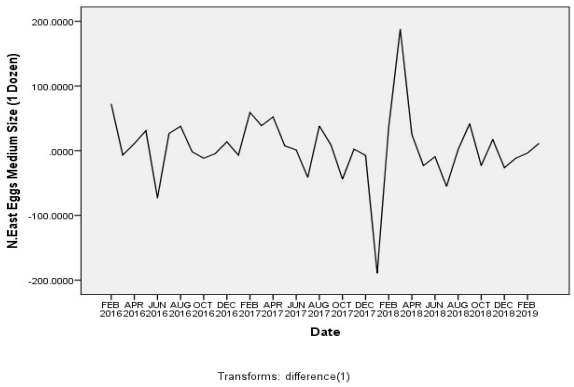

Figure 2c: Visualisation of North East zone Stationary chart using a difference of 1

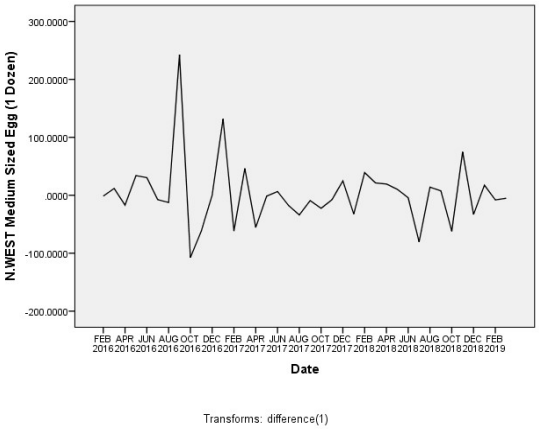

Figure 2d: Visualisation of North West zone Stationary chart using a difference of 1

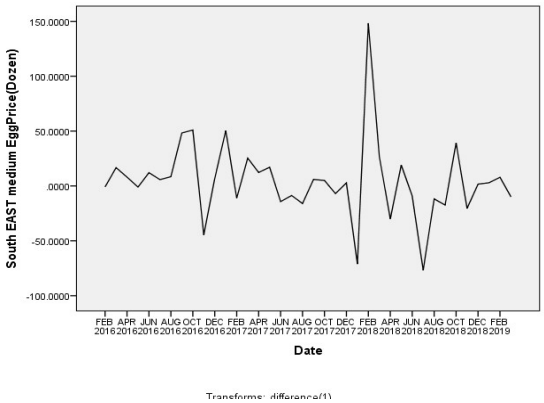

Figure 2e: Visualisation of South East zone Stationary chart using a difference of 1

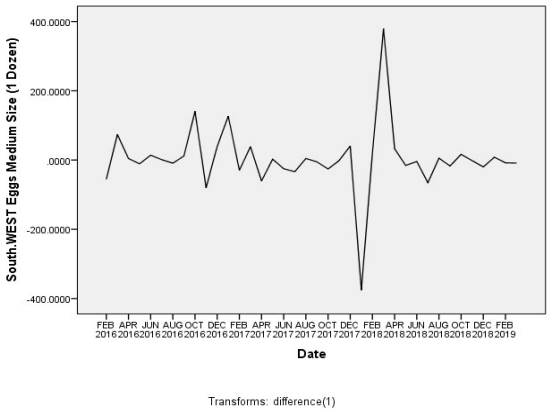

Figure 2f. Visualisation of South West zone Stationary chart using a difference of 1

4.1 Model Criterion

In this work, the Normalized Bayesian Information Criterion (BIC) was used. BIC is a criterion for model selection among a finite set of models (Etebong, 2014). Though, the model with a lower BIC is usually preferable, albeit, it should be noted that if the difference in BICs between the two models is 0–2, it is considered as 'weak' evidence in favour of the model with the smaller BIC; a difference in BICs between 2 and 6 means 'positive' evidence in favour of the model with the smaller BIC; a difference in BICs between 6 and 10 constitutes 'strong' evidence in favour of the model with the smaller BIC; and finally, the difference in BICs greater than 10 constitutes 'very strong' evidence in favour of the model with smaller BIC (Bauldry, 2015).

5. RESULT

The results of our findings is summarised in Table 3 for ARIMA (3,1,0) and Table 4 for ARIMA (3,1,1). And from the selection criterion (Normalised BIC), ARIMA (3,1,0) is a better model than ARIMA (3,1,1) for analysing the dataset under consideration (though the evidence is considered as 'weak' due to the fact that the difference in BICs between the two models are in between 0 to 2**).**

Table 3: Summary of finding using ARIMA (3,1,0)

ARIMA(3,1,0)				
Geo-Political Zone	**Normalised BIC**	**LCL (in Naira by March, 2022)**	**UCL (in Naira by March, 2022)**	**FORECAST (in Naira by March, 2022)**
South East	7.581	333.87	1,026.53	680.17
North East	8.265	103.62	1,106.57	605.09
North West	8.375	182.98	879.37	531.17
South West	9.439	-240.20	1,330.58	545.19
South South	7.827	173.37	1,049.11	611.21
North Central	8.009	129.99	977.92	553.96

Table 4: Summary of finding using ARIMA (3,1,1)

ARIMA(3,1,1)				
Geo-Political Zone	**Normalised BIC**	**LCL (in Naira by March, 2022)**	**UCL (in Naira by March, 2022)**	**FORECAST (in Naira by March, 2022)**
South East	7.706	329.54	1,030.91	680.22
North East	8.380	114.55	1,090.54	602.54
North West	8.456	156.78	895.37	526.07
South West	9.448	-312,84	1,381.89	534.53
South South	7.913	196.04	1,013.00	604.20
North Central	8.045	462.16	740.73	601.45

Furthermore, from the forecast (as at March, 2022) in all the geo-political zones in the country, there would be an increase in the price of a dozen of medium–sized eggs with both the ARIMA (3,1,0) and ARIMA (3,1,1) models. Figures 3a – 3f depict the visualisation of the forecast (for the preferred model ARIMA (3,1,0)) of the price of a dozen medium–sized eggs for the 6 geo-political zones in the country.

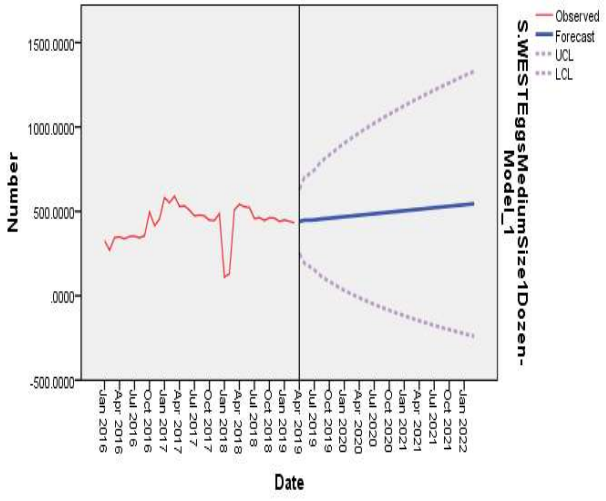

Figure 3a: Visualisation of South West price of a dozen medium-sized eggs forecast

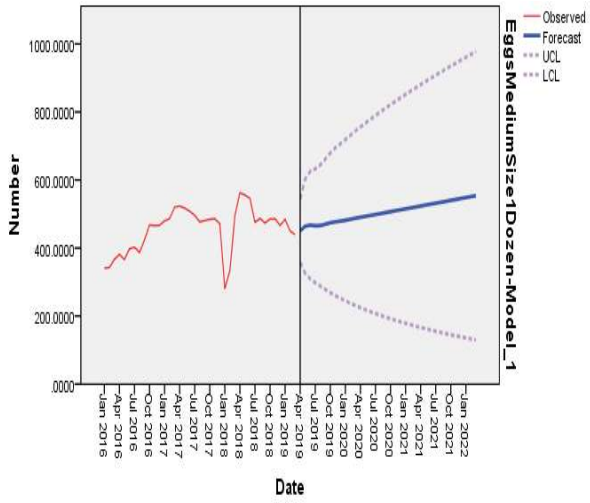

Figure 3b: Visualisation of North Central price of a dozen medium-sized eggs forecast

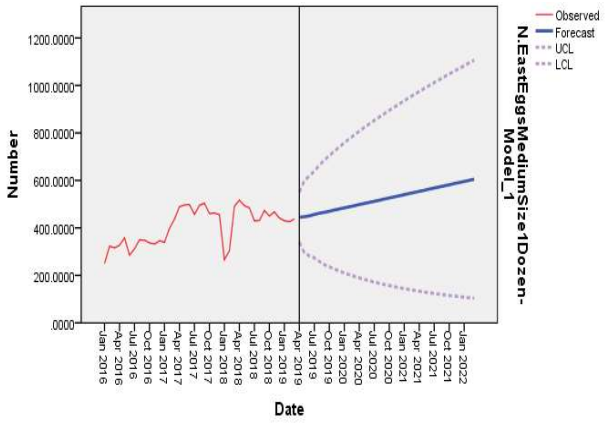

Figure 3c. Visualisation of North East price of a dozen medium-sized eggs forecast

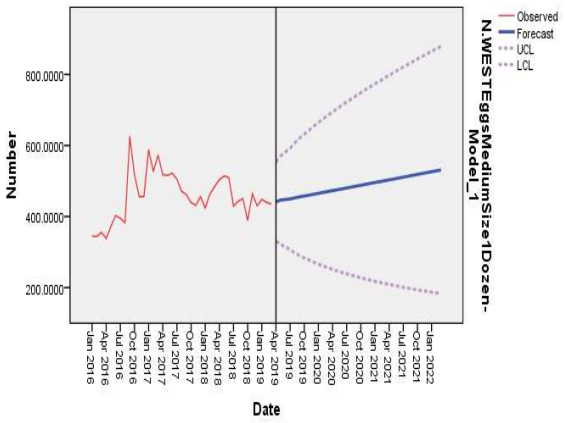

Figure 3d: Visualisation of North West price of a dozen medium–sized eggs forecast

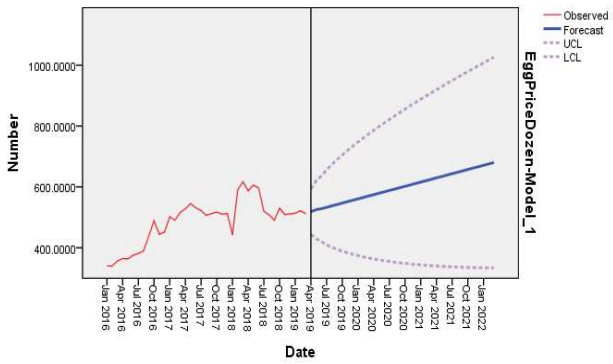

Figure 3e: Visualisation of S. East price of a dozen medium–sized eggs forecast

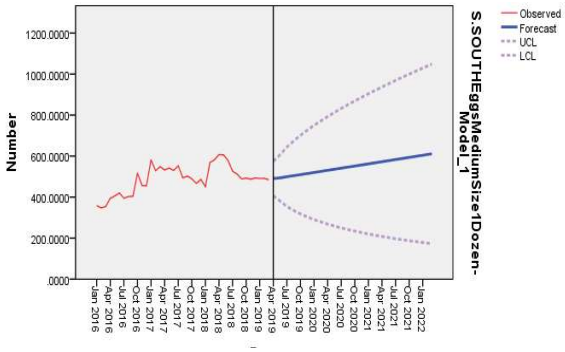

Figure 3f: Visualisation of South South price of a dozen medium–sized eggs forecast

The rising cost of eggs can be attributed to the high cost of inputs (e. g feeds) which is a major challenge in poultry business as feed purchase alone can be as high as 70% of the cost of production leading to a drastic decrease in the number of commercial poultry farmers, and even more the small-scale ones who could not cope with the production of eggs at high cost (Johnson et al, 2019). Sustainable food security should be the desire of any nation, including Nigeria. Considering the nutrient - rich nature of eggs, government should strive and engage stakeholders with policies to improve and encourage the production of eggs nationwide. Though the Nigerian government keeps attempting to abate the problem of input demand in poultry industry through programmes such as Micro-Credit Scheme for Livestock Production, Community-Based Agricultural and Rural Development Project, National Egg Production (NEGPRO) and African Chicken Genetic Gain in Nigeria (ACGG-NG) (Johnson *et al*., 2019); more still needs to be done to keep this very important protein – rich meal in the menu of the average Nigerian.

With the growing population of Nigeria, currently estimated to be 201 million people and projected to reach 401 million by 2050 persons (Mackenzie *et al.,* 2020), egg production can continue to be a lucrative business for both poultry farmers as well as investors, if the government make more concerted efforts to keep the price affordable.

5. CONCLUSION AND FUTURE STUDIES.

In this study, the prices of dozen medium sized poultry eggs across all the 6 geo-political zones in Nigeria were studied using time series (ARIMA (1,3,0) & ARIMA (1,3,1)). ARIMA (1,3,0) was found to be a better model for the dataset. The results show that the prices of eggs are on the increase in all geo-political zones in the country, with the South-South zone being the highest at N680.17/dozen with LCL & UCL of N333.87 and N1,026.53 respectively. The research also show that the North–East geopolitical zone had the highest percentage increase (73%) in a dozen price of poultry eggs within the period January 2016 - March 2019, which can be attributed in the spates of insecurity in that region. These findings can help both existing and prospective dealers in poultry eggs understand the trends in prices and hence, make informed and appropriate decisions. Furthermore, it can also help the consumers of poultry eggs to brace up in the expected increase in prices in the future.

6. RECOMMENDATIONS

One limitation during this study is the non-availability of up-to-date data of the prices of eggs in Nigeria in the data repository of the National Bureau of Statistics. It is recommended that the bureau updates its data regularly so as to present current information to enhance precise data analysis and/or forecasting results. Further studies can be done at the availability of more current and robust data.

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